referred to herein, this reference does not constitute an admission that any of these documents form part of the common general knowledge in the art, in New Zealand or in any other country.

It is acknowledged that the term 'comprise' may, under varying jurisdictions, be attributed with either an exclusive or an inclusive meaning. For the purpose of this specification, and unless otherwise noted, the term 'comprise' shall have an inclusive meaning - i.e. that it will be taken to mean an inclusion of not only the listed components it directly references, but also other non-specified components or elements. This rationale will also be used when the term 'comprised' or 'comprising' is used in relation to one or more steps in a method or process.

It is an object of the present invention to address the foregoing problems or at least to provide the public with a useful choice.

Further aspects and advantages of the present invention will become apparent from the ensuing description which is given by way of example only.

DISCLOSURE OF INVENTION

According to one aspect of the present invention there is provided an apparatus for measuring the transmission or attenuation of electromagnetic radiation through an object, said apparatus including an electromagnetic radiation emitter and detector,

characterised in that to perform transmission/attenuation measurements, the apparatus is configurable such that said emitter is positioned immediately adjacent the surface of said object and said detector is positioned on an opposing side of the object such that the detector solely, or at least substantially receives electromagnetic radiation transmitted through the object from the emitter

The present invention thus provides a means of mitigating measurement errors stemming from any detector readings of indirectly received electromagnetic radiation

not passing though the object. This is particularly useful for temperature measurements, where the transmissivity of the object to the incident electromagnetic radiation varies according to temperature.

Thus, according to one embodiment of the present invention, said apparatus is configurable to perform temperature measurements by positioning of the emitter immediately adjacent the surface of said object and positioning said detector on an opposing side of the object such that the detector solely, or at least substantially receives electromagnetic radiation transmitted through the object from the emitter.

In particular, the invention is suited to, but not restricted to, temperature measurements using microwave radiation.

According to one embodiment of the present invention there is provided an apparatus for measuring the temperature of an object, said apparatus including:

- a microwave emitter and a microwave detector

characterised in that to perform temperature measurements, said microwave emitter is positioned immediately adjacent the surface of said object and said detector is positioned on an opposing side of the object such that the microwave detector solely, or at least substantially receives microwave radiation transmitted through the object from the microwave emitter.

According to another aspect of the present invention there is provided a method of measuring the temperature of an object using microwave radiation, characterised by the steps of:

- positioning a microwave emitter immediately adjacent or in contact with a surface of said object;

- positioning a microwave detector on an opposing side of the object to said

emitter;

such that the microwave detector solely, or at least substantially receives microwave radiation transmitted through the object from the microwave emitter.

As used herein, the term object is to be interpreted widely and includes any substance, material, or organic matter, particularly those containing moisture and/or any other substance where the transmittivity of electromagnetic radiation energy changes measurably with temperature.

In one embodiment, said object is frozen, near frozen or chilled.

It will be appreciated however that the present invention is not necessarily limited to the temperature measurements of frozen or chilled objects. Alternative (non-temperature related) uses may be made of the measurements produced by the present invention.

Preferably, the present invention further includes drive apparatus capable of reversibly placing the said emitter immediately adjacent to, or in contact with, a surface of the object.

Optionally, the present invention also includes drive apparatus capable of reversibly placing the detector on an opposing side of said object to said emitter.

According to one aspect of the present invention, said drive apparatus is a linear actuator including, but not limited to, pneumatic, hydraulic, electro-mechanical operated actuators.

The drive apparatus/emitter assembly may further include a proximity sensor capable of determining the proximity of the object to the emitter. Thus, the emitter may be reliably and repeatably placed at the same degree of proximity to each object without risk of impact. In one embodiment, the proximity sensor is an ultrasonic sensor.

Preferably, said detector is positioned immediately adjacent to or in contact with said object. However, in an alternative embodiment, said detector is located proximate to, but not in contact with said object.

The present invention as described above confers a number of advantages over the prior art. There is no restriction on the object size due to the need to place the object in an enclosure. Furthermore, the possible detection of erroneous electromagnetic radiation not transmitted through the object is practically eliminated by placing the transmitter adjacent the object surface. Placing the detector (as well as the emitter) immediately adjacent or in contact with the object also aids in ensuring only microwaves transmitted through the object (or at least substantially only these microwaves) are detected. Surprisingly, it has been found that locating the detector at a short distance from the object does not necessarily corrupt accurate measurements.

The present invention is also ideally suited to rapid repeat temperature measurements of objects on a production line or the like. As there is no requirement for placing the object in a housing or enclosure, the dwell-time between measurements is not exacerbated by removing the objects from a conveyor system or the like, placing in an enclosure for measurement, and (possibly) replacing on the conveyor system. Instead, the temperature of chilled or frozen objects may be measured directly on a conveyor or similar, thus speeding throughput significantly.

Thus, according to a further embodiment, said object is placed on a moving conveyance located between the emitter and detector.

A moving conveyance includes, but is not limited to, conveyor systems, pallet handling systems, automated cargo transport systems, robotic, manual or other human operated object handling and transportation systems and the like.

Preferably, said conveyance has a primary axis of travel.

According to one aspect of the present invention, said drive apparatus is a linear actuator operating substantially orthogonally to said primary axis of the conveyance.

In embodiments using objects of highly uniform size and positioning on the conveyance means, it may be possible for the conveyance means to transport the object immediately adjacent to the emitter without the need to move the emitter, i.e., eliminating the need for an actuator.

Thus, temperature measurements of successive objects may be provided by the combined operation of said conveyance system moving successive objects along said primary axis of travel between the emitter and detector and a said linear actuator moving the emitter (and optionally) the detector into and out of contact with an object when interposed between said emitter and detector.

It is thus also possible to scan a large object by making repeated temperature measurements at different points or even continuous measurements as the emitter/detector is moved over the surface of the object.

However, it will be appreciated that the present invention need not necessarily be used in automated or multi object measurement application. The advantages of both simplified equipment over other electronic non-invasive systems together with the improved accuracy, convenience and non-invasive characteristics compared to drilled core samples favour the present invention for any scale of operation/application.

It is entirely feasible for an operator to manually place the emitter and detector on opposing sides of an object for a singular temperature measurement.

As previously stated, the inventive emitter and detector configuration may also be utilised with other forms of electromagnetic radiation and for non-temperature measurement purposes.

BRIEF DESCRIPTION OF DRAWINGS

Further aspects of the present invention will become apparent from the following description which is given by way of example only and with reference to the accompanying drawings in which:

Figure 1 shows a first side elevation of a preferred embodiment of the present invention;

Figure 2 shows a second side elevation of the embodiment shown in figure 1;

Figure 3 shows an enlarged view of the embodiment shown in figure 1, and

Figure 4 shows an enlarged view of the embodiment shown in figure 2.

BEST MODES FOR CARRYING OUT THE INVENTION

Figures 1-4 show a first embodiment of the present invention for temperature measurement of frozen meat boxes in a meat processing plant.

Figures 1 and 2 show an embodiment of the present invention in the form of a microwave temperature measurement apparatus (1), comprised of a microwave emitter (2), a microwave detector (3), support frame (4) and a moving conveyance system in the form of conveyor system (5). This embodiment is primarily configured for measuring the temperature of frozen meat placed in standard meat cartons (6). However, the temperature measurement of alternative organic produce such as cheese, fish or poultry may also be performed. Testing by the applicant has determined the successful functioning of the present invention with each such produce.

Furthermore, the use of microwave radiation is exemplary and is not limiting. Alternative forms of electromagnetic radiation may be employed according to the specific requirements of the application without departing from the inventive configuration of the emitter and detector described herein.

Figures 3 and 4 show enlarged representations of the microwave emitter and detector (2, 3), conveyor assembly (5) and carton (6). The microwave emitter (2) is located at the lower end of a drive apparatus in the form of a vertically orientated linear actuator (7) whilst the microwave detector (3) is fixed below the conveyor system (5) in a confronting relationship directly below the microwave emitter/actuator assembly (2, 7).

The microwave detector (3) and the exterior housing of the actuator (7) are secured to the support frame (4). The conveyor system (5) is formed from a plurality of cylindrical rollers (8) located transversely across the width of the conveyor (5). Meat cartons (6) are driven along the conveyor (5) either actively or under the influence of gravity by inclining the conveyor (5).

The primary axis of travel of the cartons (6) along the conveyor (5) passes between the microwave emitter and detector (2, 3) at which point a stop cylinder (9) raises from below the plane of the conveyor (5) surface to restrain the carton (6) while a temperature measurement is taken. A nudge bar (10) positions each carton laterally to align with the emitter/detector (2, 3) to account for any variation in alignment as cartons are transported on the conveyor (5).

When the carton (6) is correctly positioned by the stop cylinder (9) and nudge bar (10) between the microwave emitter and detector (2, 3) respectively, the linear actuator (7) lowers the emitter (2) to a position immediately adjacent the surface of the carton (6). The position of the emitter (2) with respect to the carton (6) is governed by an ultrasonic proximity sensor (not shown). Thus, the emitter (2) may be rapidly and repeatably placed in the same proximity to each successive carton (6) without risk of impact or the need for manual intervention. Alternative proximity, contact or position sensors may be utilized instead of an ultrasonic sensor.

The microwave emitter (2) is then activated and a pulse of microwaves (not shown) is

transmitted through the carton (6) towards the detector (3). The degree of attenuation of the transmitted microwave beam provides an indication of the temperature of the carton (6) and its contents, i.e. the frozen meat.

As the emitter is placed directly on the surface of the carton, virtually all the microwaves emitted have to travel through the carton (6) before being either absorbed, or detected by the detector (3). This configuration reduces the possibility for any external reflection, refraction or other indirect routes from the emitter (2) to the detector (3).

Although the above embodiment shows the use of temperature measurements with a standard sized meat container, it will be appreciated that a variety of other objects/containers may be employed by configuring and dimensioning the present invention (1) accordingly. It will be further appreciated that alternative conveyance means to the conveyor system (5) may be employed.

In the embodiment shown, the microwave detector (3) is positioned a short distance below the carton (6) to allow for the passage of the conveyor system (5). It will be appreciated that in other embodiments, the detector (3) may be placed in contact with or immediately adjacent to the surface of the carton (6) to ensure no extraneous reflected or refracted microwaves are received by the detector (3). It has been found in practice however that separating the detector (3) from the surface of the object being the temperatures being measured (6) does not cause any appreciable degradation in the temperature measurement. Nevertheless, alternative detector/conveyor systems (3, 5) may be configured to permit placement of the detector (3) in contact with, or immediately adjacent to, the cartoon (6).

In yet further embodiments, the emitter (2) and detector (3) may be manually placed in position about the carton (6) to effect a single temperature measurement, as may be required for random sampling checks and the like.

Thus, by virtue of the aforementioned configuration, the present invention provides an apparatus and a method for measuring the transmission/attenuation of electromagnetic radiation transmitted through a sample without erroneous measurements from non-transmission radiation and without need to place the said objects in a measurement enclosure and without obstructing the throughput of objects in continuous production/packaging or storage applications.

Aspects of the present invention have been described by way of example only and it should be appreciated that modifications and additions may be made thereto without departing from the scope thereof.

Claims:

1. An apparatus for measuring the transmission or attenuation of electromagnetic radiation through an object, said apparatus including an electromagnetic radiation emitter and detector,

   characterised in that to perform transmission/attenuation measurements, the apparatus is configurable such that said emitter is positioned immediately adjacent the surface of said object and said detector is positioned on an opposing side of the object such that the detector solely, or at least substantially receives electromagnetic radiation transmitted through the object from the emitter.

2. The apparatus as claimed in claim 1, wherein said apparatus is configurable to perform temperature measurements by positioning of the emitter immediately adjacent the surface of said object and positioning said detector on an opposing side of the object such that the detector solely, or at least substantially receives any electromagnetic radiation transmitted through the object from the emitter.

3. The apparatus as claimed in claim 1 or claim 2, wherein said object includes any substance, material, or organic matter containing moisture and/or any other substance where the transmittivity of electromagnetic radiation energy changes measurably with temperature.

4. The apparatus as claimed in any one of the preceding claims, wherein said object is frozen, near frozen or chilled.

5. The apparatus as claimed in any one of the preceding claims, further including drive apparatus capable of reversibly placing the said emitter immediately adjacent or in contact with a surface of the object.

6. The apparatus as claimed in claim 5, wherein said drive apparatus is capable of reversibly placing the said microwave detector on an opposing side of said object to said emitter.

7. The apparatus as claimed in any one of claims 5 - 6, wherein said drive apparatus is a pneumatic, hydraulic, or electro-mechanical operated linear actuator.

8. The apparatus as claimed in any one of claims 5 - 7, wherein the drive apparatus/emitter assembly further includes a proximity sensor capable of determining the proximity of the object to the emitter.

9. The apparatus as claimed in claim 8, wherein the proximity sensor is an ultrasonic sensor.

10. The apparatus as claimed in any one of the preceding claims, wherein said detector is positionable immediately adjacent to, or in contact with, said object.

11. The apparatus as claimed in any one of claims 1-9, wherein said detector is located proximate to, but not in contact with said object.

12. The apparatus as claimed in any one of the preceding claims, further including a moving conveyance configured to transport a plurality of objects along a primary axis of travel passing between the emitter and detector.

13. The apparatus as claimed in claim 12, wherein the moving conveyance includes conveyor systems, pallet-handling systems, automated cargo transport systems, robotic, manual or human-operated object handling and/or transportation systems.

14. The apparatus as claimed in any one of claims 1-4, wherein the microwave emitter and detector are manually positionable on opposing sides of an object

for temperature measurement.

15. A method of measuring the transmission or attenuation of electromagnetic radiation through successive objects using the apparatus claimed in claim 12 or 13, comprising the steps;

- successively transporting objects via said conveyance system between the emitter and detector along the primary axis of travel;
- positioning the emitter adjacent to, or in contact with, each object when interposed between said emitter and detector;
- performing an electromagnetic radiation transmission or attenuation measurement;
- moving the emitter away from the object.

16. The method as claimed in claim 15 including the further step of;

- positioning the detector adjacent to, or in contact with, each object when interposed between said emitter and detector prior to performing the electromagnetic radiation transmission or attenuation measurement;
- moving the detector away from the object.

17. An apparatus for measuring the temperature of an object, said apparatus including:

- a microwave emitter and a microwave detector;

characterised in that to perform temperature measurements, said microwave emitter is positionable immediately adjacent the surface of said object and said detector is positioned on an opposing side of the object such that the microwave detector solely, or at least substantially receives microwave

radiation transmitted through the object from the microwave emitter.

18. A method of measuring temperature of an object using microwave radiation, characterised by the steps of:

    - positioning a microwave emitter immediately adjacent or in contact with a surface of said object;

    - irradiating the object with microwave radiation from the emitter;

    - positioning a microwave detector on an opposing side of the object to said emitter such that microwave detector solely, or at least substantially receives microwave radiation transmitted through the object from the microwave emitter.

    - calculating the object temperature from said microwave radiation received by the detector.

19. An apparatus substantially as hereinbefore described with reference to, and as shown in the drawings.

20. A method substantially as hereinbefore described with reference to, and as shown in the drawings.